MINE PLAN OF OPERATIONS

ADDENDUM

TWIN METALS MINNESOTA PROJECT

Environmental Review Support Document

Prepared for Twin Metals Minnesota LLC
Prepared by Foth Infrastructure & Environment, LLC

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LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ABA	acid-base accounting
ARD	acid rock drainage
BLM	Bureau of Land Management
gpm	gallon per minute
HCT	Humidity Cell Testing
ML	metal leaching
MPO	Mine Plan of Operations
NAG	Net Acid Generation
QEMSCAN	quantitative evaluation of minerals
TMM	Twin Metals Minnesota LLC
XRF	x-ray fluorescence

1.0 INTRODUCTION

This addendum provides information requested by the Department of the Interior – Bureau of Land Management (BLM) to complete the Mine Plan of Operations (MPO). A letter addressed to Twin Metals Minnesota LLC (TMM) dated March 19, 2020 requested:

- A list of the federal leases, lease applications, and permits within the Project area of the MPO, or otherwise affected by the MPO.
- A map showing the full extent of any federal leases, lease applications, and permits within the Project area of the MPO, or otherwise affected by the MPO.
- The Hydrology Characterization Data Package, Volumes 1-3, or a summary that meets the requirements as set forth in 43 CFR 3592.1(c)(8)(i).

The information supplied in this addendum satisfies the applicable requirements and provides the information necessary for the BLM to consider the MPO complete.

2.0 FEDERAL LEASE INFORMATION REQUEST

The letter submitted by the BLM included two requests for additional information regarding federal lease information. The requests, and the information to satisfy those requests, are as follows:

1) Please provide a list of the federal leases, lease applications, and permits within the project area of the MPO, or otherwise affected by the MPO.

Table 1 identifies federal leases, lease applications, and permits within the Project area of the MPO, or otherwise affected by the MPO. The federal lease, lease application, and permit information provided in Table 1 reflects information which was reasonably available. Federal prospecting permits listed below are included because they fall within the boundary of the Project area; however, the MPO does not include any mining in federal prospecting permit areas.

Table 1 – Federal Lease Information

Surface Ownership Class	Owner Name	Mineral Lessee	Mineral Ownership Class	Mineral Owner Name	Mineral Status	Mineral Lease Permit No. (Primary)	Mineral Ownership Percentage
Federal	USA	Beaver Bay, Inc.	Federal	USA	PRL	MNES-1352	100
Private	SKA & Members	Beaver Bay, Inc.	Federal	USA	PRL	MNES-1352	100
Private	Allete Inc	Beaver Bay, Inc.	Federal	USA	PRL	MNES-1352	100
Private	Franconia Minerals (US) LLC	Beaver Bay, Inc.	Federal	USA	PRL	MNES-1352	100

Surface Ownership Class	Owner Name	Mineral Lessee	Mineral Ownership Class	Mineral Owner Name	Mineral Status	Mineral Lease Permit No. (Primary)	Mineral Ownership Percentage
Federal	USA	Twin Metals Minnesota LLC	Federal	USA	PRLA	MNES-057965	100
Federal	USA	Twin Metals Minnesota LLC	Federal	USA	Federal Prospecting Permit	MNES-54196	100
Federal	USA	Twin Metals Minnesota LLC	Federal	USA	Federal Prospecting Permit	MNES-55305	100
Federal	USA	Lehmann Exploration Management Inc.	Federal	USA	Federal Prospecting Permit	MNES-54387	100
Federal	USA	Lehmann Exploration Management Inc.	Federal	USA	Federal Prospecting Permit	MNES-53731	100
Federal	USA	Franconia Minerals (US) LLC	Federal	USA	Federal Prospecting Permit	MNES-58222	100

2) Please provide a map showing the full extent of any federal leases, lease applications, and permits within the project area of the MPO, or otherwise affected by the MPO.

Figure 1 shows the full extent of the federal leases, lease applications, and permits within the Project area of the MPO, or otherwise affected by the MPO, which are identified in Table 1.

3.0 INFORMATION TO SATISFY 43 CFR 3592.1(C)(8)(I)

The BLM has requested The Hydrology Characterization Data Package, Volumes 1-3, or a summary that meets the requirements as set forth in 43 CFR 3592.1(c)(8)(i):

> *An estimate of the quantity of water to be used and pollutants that may enter any receiving waters.*

For the purposes of satisfying this request, this section contains a summary of the proposed water use, identifies the potential receiving waters, and discusses potential pollutants currently being analyzed or identified. The potential receiving waters identified are those that are downgradient of the facilities, but do not represent a comprehensive pollutant transport assessment, which is anticipated as part of future submittals. TMM plans to submit the hydrology data package volumes with updated information in the future; however, additional data collection and updates to the package are ongoing.

3.1 Water Use

The submitted MPO Section 2.13 (MPO, 2019) described how water would be managed at the facility and the sources of water. The water use strategy would follow the following priority order for water sources:

1. Reuse of process water;
2. Use of mine inflow;
3. Use of contact water; and
4. Make-up water from Birch Lake reservoir.

Figure 2 provides a simplified Project water schematic illustrating how water would move throughout the Project. Figure 2 also provides estimated percentages of total makeup water for mine inflow, precipitation that would be collected contact water, and appropriations from Birch Lake reservoir, which would serve as make-up water only when process demand cannot be met by mine inflow and contact water. As discussed in Section 2.13 (MPO, 2019), the average annual withdrawal from Birch Lake reservoir is anticipated to be between 75 to 130 million gallons of water per year. This equates to an average annual withdrawal of 140 to 250 gallons per minute (gpm); however, to meet process demand and the variation in climatic conditions, the instantaneous rate of pumping from Birch Lake reservoir is approximately 800 gpm. Within the average water balance, preliminary assessments indicate Project makeup water needs are met by the following: contact water (precipitation collection) (~40%), mine inflow (~34%), and withdrawal from Birch Lake reservoir (~26%). These percentages are variable throughout the life of the Project due to mine inflow varying with the progression of the mine, precipitation varying with climate conditions, and Birch Lake make-up need varying as a result of increases or decreases in mine inflow and precipitation.

3.2 Analysis of Potential for Pollutants to Enter Receiving Waters

We analyzed the potential for pollutants to enter receiving waters from the plant site contact and process water ponds and tailings management facility contact water ponds and ditches. It is not anticipated that potential pollutants would be stored at the ventilation raise sites, water intake facility, within the non-contact water diversion area, along access roads, or within the transmission corridor. Based on the locations of ponds and ditches and the predominant surface drainage directions, the waters analyzed for potential to receive pollutants include Keeley Creek, North Nokomis Creek, and Birch Lake reservoir (Figure 3). The following is a discussion of the environmental protection measures incorporated into the Project and the pollutants associated with the Project.

3.2.1 Environmental Protection Measures

The Project has been designed to minimize the ability of pollutants to reach potential receiving waters; this has been accomplished by incorporating environmental protection measures into the Project and management plans which guard against the physical migration of potential pollutants. The environmental protection measures

that have been incorporated into the Project are outlined in Section 4.1 (MPO, 2019). The following is a review of those measures specifically to protect water resources:

- The potential for run-on would be minimized through implementation of diversion dikes and non-contact water ditches described in Appendix C (MPO, 2019).
- The process water pond would be double lined with leak detection as described in Section 2.13.3 (MPO, 2019).
- All contact water ponds would be single lined as discussed in Section 2.13.3 (MPO, 2019).
- Contact water ponds would be sized to contain the 100-year, 24-hour storm event. In addition, the collective storage capacity of the contact water ponds for the lined dry stack facility would be sized to meet the stormwater runoff requirements from a 100-year snowpack.
- The dry stack facility would be lined as described in Section 2.5.5 (MPO, 2019).
- The dry stack facility would include an under-liner drainage system to protect groundwater resources if seepage occurs as described in Section 2.5.5 (MPO, 2019).
- The dry stack facility would include over-liner drains and a blanket toe drain to capture draindown intercepted by the liner at the base of the dry stack facility.
- A cover would be placed on the lined dry stack facility. The cover at closure is anticipated to consist of at least 2 feet of cover soil underlain by a hydraulic barrier.
- A grout curtain would be installed during construction of the lined dry stack facility to protect water resources in the event the dry stack facility produces seepage.
- The lined dry stack facility design avoids direct impacts to Keeley Creek through the implementation of ponds, ditches, and water conveyances and sited to avoid direct impacts to Keeley Creek.
- Pipes containing petroleum products, liquid reagents, or processing fluids would be double-walled and/or would have a system of leak detection and secondary containment, as determined to be necessary.
- Reclamation material stockpiles would be covered with wood chips and revegetated to prevent erosion.

In addition to these design parameters, Sections 4.2.1 and 4.2.2 (MPO, 2019) detail operational practices for general water management and facility-specific water management, respectively, which have been developed with the specific intention of minimizing the potential release of pollutants.

3.2.2 Hazardous Materials

The anticipated hazardous materials and chemical constituents to be used during the operational phase of the Project, as well as their anticipated quantities, include those listed in Tables 2-6 (Primary Fuels) and 2-7 (Primary Reagents) of the MPO (MPO, 2019). A consolidated list of these materials, as well as the response plans should a

release occur, can be found in Section 6.3 of Appendix F: Spill Contingency Plan (MPO, 2019) and is as follows:

- Lime – Calcium Oxide
- Sulfuric Acid
- Triethylenetetramine
- Sodium Sulfite
- Aerophine 3418A
- Sodium Isopropyl Xanthate
- Methyl Isobutyl Carbinol
- Copper Sulfate
- Hydraulic Fluid
- Emulsion (Titan® 7000)
- Gasoline and Diesel Fuel
- Propane
- Automatic Transmission Fluid
- Bulk Oils
- Ethylene Glycol (Antifreeze)

Appendix F (MPO, 2019) also discusses material handling requirements, containment structures, and other operational practices designed to minimize the potential release of pollutants.

3.2.3 Materials Characterization

In addition to the materials listed in Section 3.2.2 of this document, TMM continues to conduct materials characterization program in accordance with Minnesota Department of Natural Resources requirements. This work currently identifies the potential constituents that could be present in process and contact water ponds and ditches. When completed, the program would refine the list of potential pollutants related to materials characterization (outlined in Table 2), as well as inform future environmental protection measures or other design considerations to manage and mitigate the potential for any of the constituents migrating to receiving waters.

TMM has been working with Golder Associates Inc. since 2012 to develop a robust materials characterization program (program) that assesses the potential environmental behavior of mine and geologic materials expected to be present at the Project. The following information is summarized from the work plans associated with this program. The program is designed to address the following matters:

- Potential for acid rock drainage (ARD)
- Potential for metals leaching under acidic, neutral, or alkaline conditions
- Potential for discharges of sulfate and other non-metallic constituents
- Potential for labile mercury
- Potential for labile (asbestiform) fibers
- Potential for radon generation in the underground

The program goal is to analyze these potential issues and provide an evaluation of Project environmental geochemistry through both static (short-term) and kinetic (long-term) testing as not only a stand-alone analysis, but also as an input of data for other modeling efforts.

Static Testing

Static testing is conducted to describe bulk chemical characteristics of a material. As it relates to the Project, the purpose of static testing is to identify the potential of particular rock types to leach metals or generate acid. Static testing results may initially indicate a potential for ARD and/or metal leaching (ML) but kinetic testing is required to verify if the potential would be realized.

The static testing program is comprised of the following tests:

Acid-Base Accounting (ABA)

ABA is conducted to predict the acid generation characteristics of a material and is based on the relative difference between the material's net acid generation potential and net acid neutralization potential. The acid generation potential of a sample is estimated based on its total sulfur or sulfide sulfur content. Neutralization potential is determined by titration or calculated based on carbon or total inorganic carbon content.

Chemical Analysis (Elemental and Whole Rock Analysis)

Characterization of a material's chemical composition is fundamental to understanding its environmental behavior. The results from solid-phase chemical analysis can be used to infer which elements are of potential environmental concern, although a high concentration of a particular element does not necessarily imply that this element would indeed be mobilized in concentrations that may lead to environmental impacts. Two methods would be used to determine chemical composition:

- Elemental Analysis: Elemental composition would be determined using an acid digestion to release elements into the solution phase followed by analysis of the elements in the resulting digestion.
- Whole Rock Analysis: Whole rock analysis is performed by x-ray fluorescence (XRF), an analytical method used for chemical characterization of major elements in materials through the use of x-ray excitation and measurement of secondary fluorescence radiation from energy or wavelength-dispersed spectrum.

Net Acid Generation Testing (NAG test)

The NAG test determines the ARD potential of a sample. The NAG test procedure uses a strong oxidant (hydrogen peroxide) to rapidly oxidize sulfide minerals in a crushed rock sample. The neutralization potential can then be directly challenged by the acidity generated by rapidly oxidizing sulfides. If the sample has sufficient

available NP, the alkalinity of the whole rock would not be entirely depleted, and the system is expected to have the capacity to remain circum-neutral. If there is inadequate available NP, then the pH of the test solution would fall below 4.5 and there would be net acidity rather than net alkalinity. In this case, a sample shows potential for acid generation.

This test may also be used to evaluate metal leaching through analysis of the NAG test leachate.

Mineralogical and Petrological Analysis

Mineralogical Analysis: Mineralogical analysis is conducted to identify and quantify both the crystalline and amorphous phases present in rock samples. In combination with the bulk chemical characteristics, the mineralogical information can be used to explain and predict the ARD/ML potential of the materials tested. Mineralogical findings, specifically the absence or presence of sulfide and carbonate mineral phases, are considered in the interpretation of ABA results.

Petrological Analysis: Petrology is the study of the composition, origin, structure, and formation of rocks. Petrography, a branch of petrology, focuses on the description and classification of rocks through the use of microscopic examination. The objective of petrological analysis by microscopic examination is to characterize mineral modal abundance, mineral grain size, mineral texture, and mineral alteration. Petrological analysis would focus on sulfide and neutralization (i.e., carbonates and silicates) characterization.

Mineralogical and petrological analysis would use a number of techniques, including:

- Visual Logging
- X-ray diffraction with Rietveld refinement
- Quantitative evaluation of minerals by scanning electron microscopy (QEMSCAN)
- Optical microscopy
- Electron microprobe

Kinetic Testing

Kinetic testing evaluates the weathering behavior of mine materials under defined conditions. For samples that do show reactivity, kinetic testing indicates field-scale leaching over time.

The kinetic testing program is comprised of the following tests:

Humidity Cell Testing (HCT)

HCT testing is conducted to evaluate the weathering behavior of a sample over time under exposed conditions. This test involves weekly flushing of a 1-kilogram sample with deionized water. Leachates are filtered and analyzed for dissolved analytes to determine soluble minerals in the weathered samples and to estimate lag times to

acid generation. Testing is typically conducted for a minimum 20-week period, but testing may need to be extended for "uncertain" or slow-reacting materials. Early flush results can indicate the presence of acid salts. Later results are indicative of long-term conditions and are used to estimate release rates of sulfates and metals.

Diffusion Testing

Diffusion testing is conducted to evaluate the weathering behavior of a sample over time under submerged conditions. The potential for constituent leaching from a sample by diffusive processes is evaluated by submerging the sample in a container of deionized water for variable periods of time (i.e., hours) and analyzing the resultant leachate for dissolved analytes.

Testing Parameters

The materials characterization program includes the testing parameters outlined in Table 2, which have been developed in collaboration with the Minnesota Department of Natural Resources and in accordance with requirements outline in Chapter 6132, Section 1000 of the Minnesota Administrative Rules.

Table 2 – Materials Characterization Program – Testing Parameters

Conventional Parameters	Unit
pH	s.u.
Eh	mV
Temperature	°C
Specific Conductance	µS/cm
Total Dissolved Solids	mg/L
Major Ions	**Unit**
Alkalinity	mg/L as $CaCO_3$
Acidity	mg/L as $CaCO_3$
Sulfate (SO_4)	mg/L
Chloride (Cl)	mg/L
Fluoride (F)	mg/L
Calcium (Ca	µg/L

Major Ions	Unit
Magnesium (Mg)	µg/L
Potassium (K)	µg/L
Sodium (Na)	µg/L

Nutrients	Unit
Nitrate + Nitrite (NO_3)	mg/L-N
Ammonia (NH_3)	mg/L-N
Phosphorus (P)	mg/L

Metals	Unit
Aluminum (Al)	µg/L
Antimony (Sb)	µg/L
Arsenic (As)	µg/L
Barium (Ba)	µg/L
Beryllium (Be)	µg/L
Boron (B)	µg/L
Cadmium (Cd)	µg/L
Chromium (Cr)	µg/L
Cobalt (Co)	µg/L
Copper (Cu)	µg/L
Iron (Fe)	µg/L
Lead (Pb)	µg/L
Lithium (Li)	µg/L
Manganese (Mn)	µg/L
Mercury (Hg)	µg/L
Molybdenum (Mo)	µg/L

Metals	Unit
Nickel (Ni)	µg/L
Selenium (Se)	µg/L
Silicon (Si)	µg/L
Silver (Ag)	µg/L
Strontium (Sr)	µg/L
Sulfur (S)	µg/L
Thallium (Tl)	µg/L
Thorium (Th)	µg/L
Tin (Sn)	µg/L
Titanium (Ti)	µg/L
Uranium-238 (U)	µg/L
Vanadium (V)	µg/L
Zinc (Zn)	µg/L

Materials Characterization Deliverables

The materials characterization work plan systematically identifies the constituents that may be present, derives the potential concentrations and the potential vectors for transport into the environment. The results of executing the work plan will refine the list of potential pollutants and receiving waters. TMM's materials characterization program is anticipated to culminate in the following volumes of work:

- Volume I – Project Documentation Overview
- Volume II – Project Description
- Volume III – Mine Waste Characterization Work Plan
- Volume IV – Mine Waste Characterization Work Plan Implementation
- Volume V – Mine Waste Characterization Work Plan Testing Results
- Volume VI – Mine Water Quality Predictions
- Volume VII – Supplementary Evaluations

As previously discussed, Table 2 identifies the list of parameters the materials characterization program analyzes. The purpose of the program is to refine the list of potential pollutants, as well as identify the source points of potential pollutants remaining on the list, and use these data points within the surface and groundwater

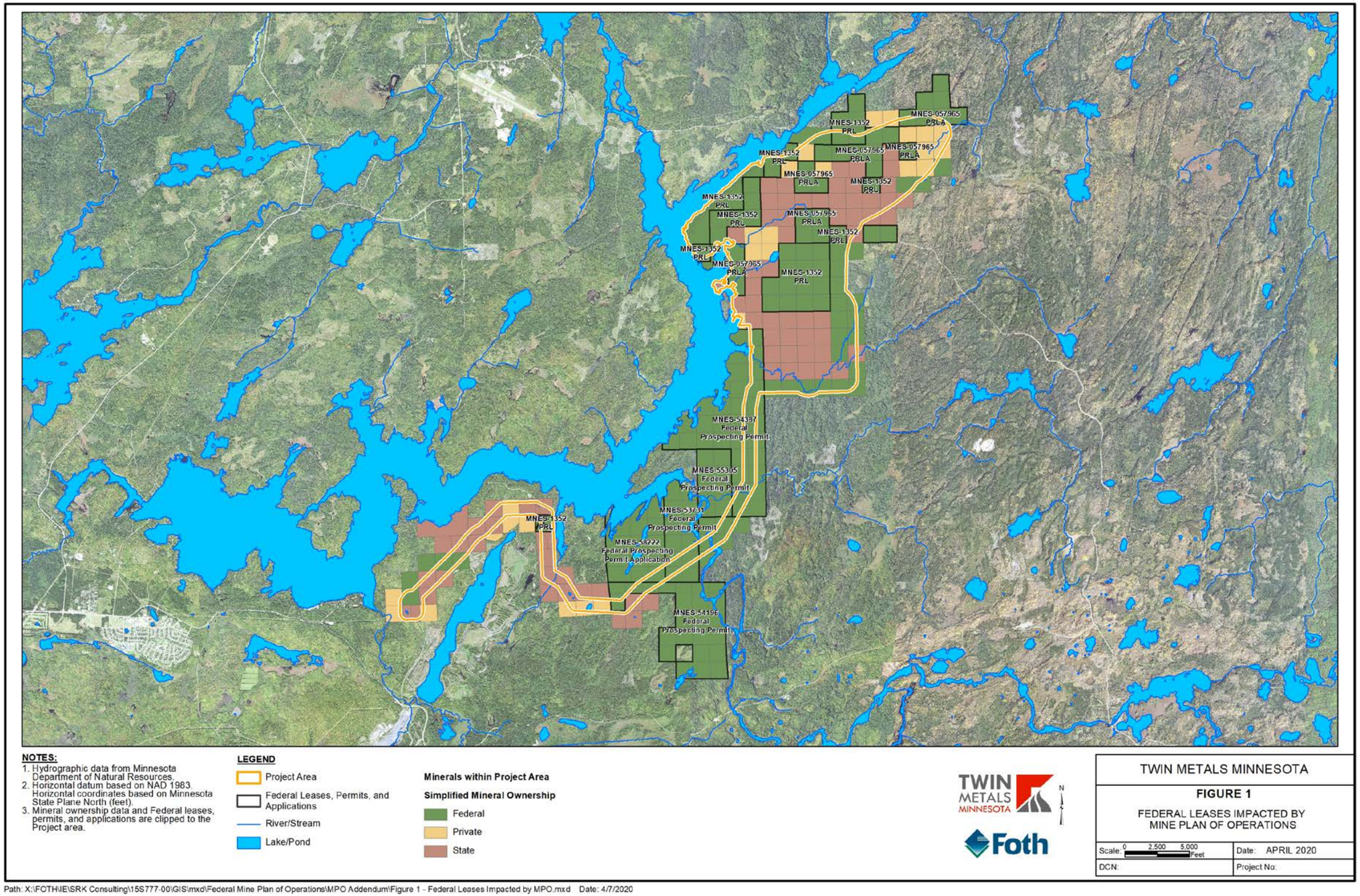
modeling efforts. These efforts, culminating in Hydrology Characterization Data Packages, Volumes 1-3, would allow TMM to understand and manage the physical ability of potential pollutants to migrate to receiving waters.

4.0 REFERENCE

Twin Metals Minnesota LLC, 2019. Mine Plan of Operations.

FIGURES

Figure 1 – Federal Leases Impacted by Mine Plan of Operations



Path: X:\FOTH\IE\SRK Consulting\15S777-00\GIS\mxd\Federal Mine Plan of Operations\MPO Addendum\Figure 1 - Federal Leases Impacted by MPO.mxd Date: 4/7/2020

Figure 2 – Simplified Project Water Schematic

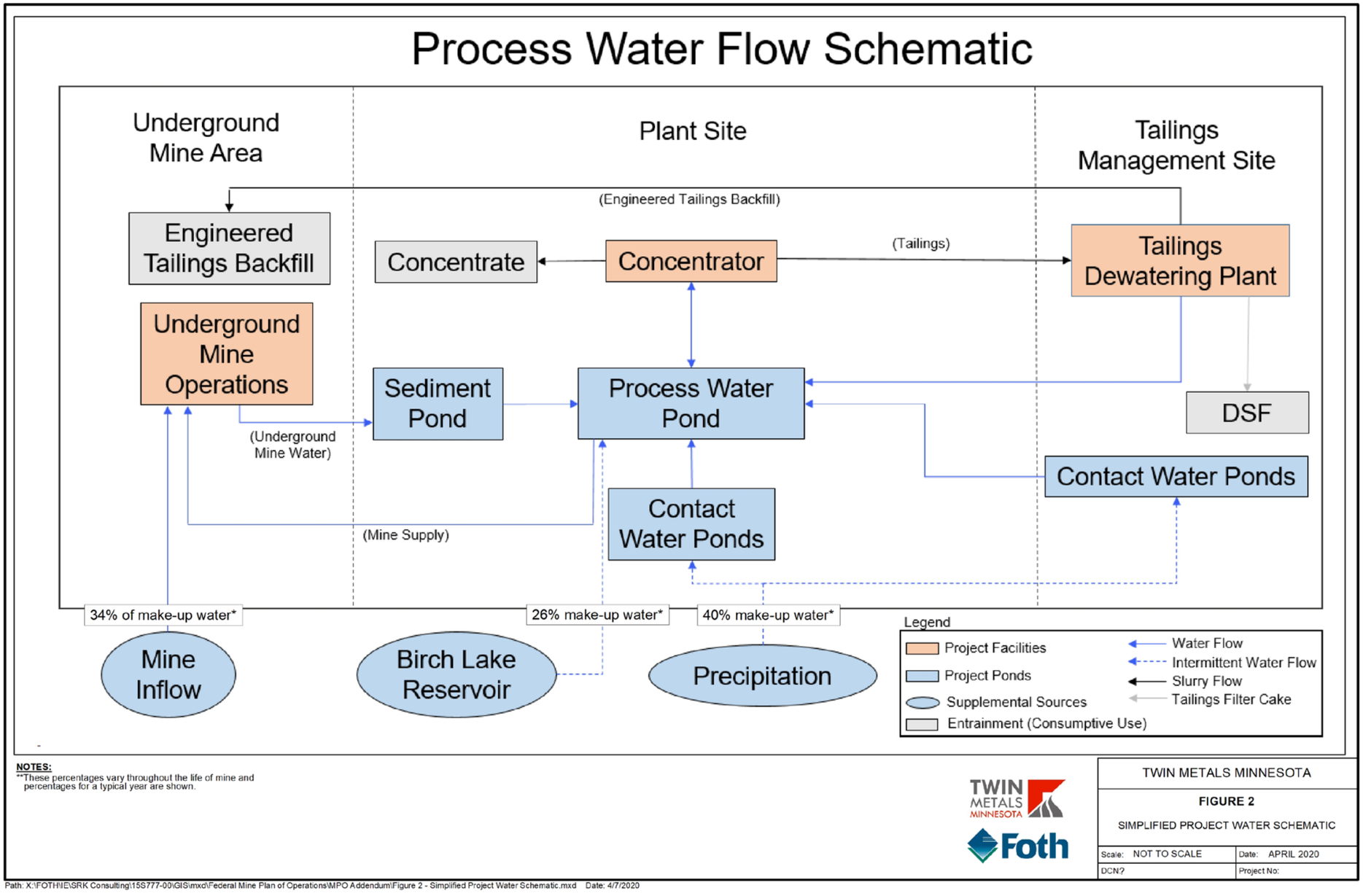
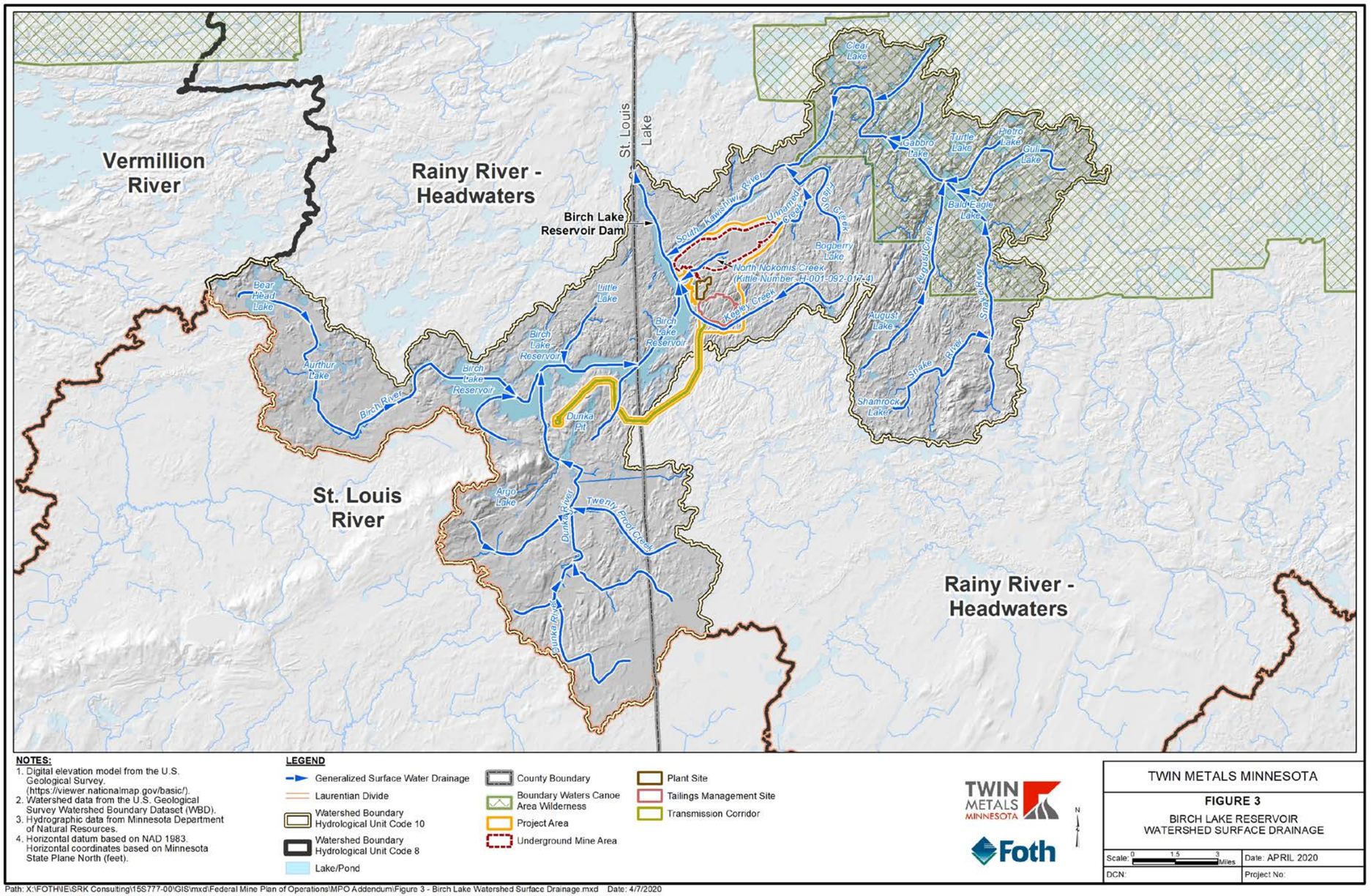



Figure 3 – Birch Lake Reservoir Watershed Surface Drainage